openheart

Home-based versus centre-based cardiac rehabilitation: abridged Cochrane systematic review and meta-analysis

S A Buckingham,[1] R S Taylor,[2] K Jolly,[3] A Zawada,[4] S G Dean,[2] A Cowie,[5] R J Norton,[6] H M Dalal[1,2]

To cite: Buckingham SA, Taylor RS, Jolly K, *et al*. Home-based versus centre-based cardiac rehabilitation: abridged Cochrane systematic review and meta-analysis. *Open Heart* 2016;**3**:e000463. doi:10.1136/openhrt-2016-000463

► Additional material is available. To view please visit the journal (http://dx.doi.org/10.1136/openhrt-2016-000463).

Paper based on: Taylor RS, Dalal H, Jolly K, *et al*. Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev* 2015;(8):CD007130.

Received 28 April 2016
Revised 24 June 2016
Accepted 19 July 2016

For numbered affiliations see end of article.

Correspondence to
Professor RS Taylor;
r.taylor@exeter.ac.uk

ABSTRACT

Objective: To update the Cochrane review comparing the effects of home-based and supervised centre-based cardiac rehabilitation (CR) on mortality and morbidity, quality of life, and modifiable cardiac risk factors in patients with heart disease.

Methods: Systematic review and meta-analysis. The Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, PsycINFO and CINAHL were searched up to October 2014, without language restriction. Randomised trials comparing home-based and centre-based CR programmes in adults with myocardial infarction, angina, heart failure or who had undergone coronary revascularisation were included.

Results: 17 studies with 2172 patients were included. No difference was seen between home-based and centre-based CR in terms of: mortality (relative risk (RR) 0.79, 95% CI 0.43 to 1.47); cardiac events; exercise capacity (mean difference (MD) −0.10, −0.29 to 0.08); total cholesterol (MD 0.07 mmol/L, −0.24 to 0.11); low-density lipoprotein cholesterol (MD −0.06 mmol/L, −0.27 to 0.15); triglycerides (MD −0.16 mmol/L, −0.38 to 0.07); systolic blood pressure (MD 0.2 mm Hg, −3.4 to 3.8); smoking (RR 0.98, 0.79 to 1.21); health-related quality of life and healthcare costs. Lower high-density lipoprotein cholesterol (MD −0.07 mmol/L, −0.11 to −0.03, p=0.001) and lower diastolic blood pressure (MD −1.9 mm Hg, −0.8 to −3.0, p=0.009) were observed in centre-based participants. Home-based CR was associated with slightly higher adherence (RR 1.04, 95% CI 1.01 to 1.07).

Conclusions: Home-based and centre-based CR provide similar benefits in terms of clinical and health-related quality of life outcomes at equivalent cost for those with heart failure and following myocardial infarction and revascularisation.

BACKGROUND

Mortality from coronary heart disease (CHD) in developed nations has fallen over the past three decades; however, CHD still accounts for around 20% of deaths in Europe.[1] In the UK, around 110 000 men and 65 000 women are admitted with acute coronary syndrome every year and it is estimated that there are 2.3 million people living with CHD.[2]

Cardiac rehabilitation (CR) is offered to individuals after cardiac events in order to facilitate recovery and prevent relapse by optimising cardiovascular risk reduction, fostering healthy behaviours and compliance to these behaviours, and promoting an active lifestyle.[3] While a central component is exercise training,[4 5] it is recommended that CR programmes provide lifestyle education on CHD risk factor management plus counselling and psychological support—so-called 'comprehensive CR'.[6 7] Such programmes are designed to limit the physiological and psychological effects of cardiac illness, reduce the risk for sudden death or reinfarction following myocardial infarction (MI), control cardiac symptoms, stabilise or reverse the atherosclerotic process, and enhance the psychosocial and vocational status of selected patients (eg, by improving functional capacity to support early return to work[7]).

Recent Cochrane reviews demonstrate that CR improves health-related quality of life (HRQoL) and reduces hospital admissions compared with usual care in various patient groups including those with MI, heart failure and following percutaneous coronary intervention and coronary artery bypass graft.[8 9] National and international professional guidelines including the National Institute for Health and Care Excellence (NICE) in the UK, the American Heart Association/American College of Cardiology, and the European Society of Cardiology recommend CR as an effective and safe intervention in the management of CHD and heart failure.[10–15]

Despite these apparent benefits and recommendations, participation in CR in the UK and abroad remains suboptimal, particularly for heart failure.[16 17] A 2012 UK-based

survey found that only 16% of CR centres provided a programme specifically designed for people with heart failure; commonly cited reasons for the lack of provision of CR were a lack of resources and exclusion from commissioning agreements.[16] Two main reasons given by patients for failing to take part in CR are difficulties with regular attendance at their local hospital and reluctance to join group-based classes.[18]

Home-based rehabilitation programmes have been introduced as an alternative to the conventional centre-based CR to widen access and participation. For example, the Heart Manual (developed by National Health Service (NHS) Lothian) is a self-help manual supported by a trained professional, which is designed to assist in recovery and improve patients' understanding and management of their condition following MI, and is now widely used in the UK, Italy, Canada, Australia and New Zealand.[19 20]

While the previous Cochrane review found home-based and centre-based CR programmes to be equally effective in improving participant outcomes,[21 22] the majority of evidence was in low-risk patients following MI or revascularisation. We are aware of a number of randomised head-to-head trials of centre-based versus home-based CR in heart failure that have been published since the previous review.[23–25]

The aim of this study was to update the previous (2010) Cochrane systematic review and meta-analysis of the randomised controlled trial evidence comparing home-based and centre-based CR.

METHODS

We conducted and reported this systematic review in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.[26]

Search methods for identification of studies

The search strategy was designed in accordance with the previous Cochrane review and used both controlled vocabulary (eg, Medical Subject Headings (MeSH)) and key words ('heart disease and (synonym)' and 'rehabilitation or exercise or (synonym)') combined with a randomised controlled trial filter.[21] The list of studies was updated with electronic searches of the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE, PsycINFO and CINAHL plus (see online supplementary material file, eg). Databases were searched from January 2008 (end date of previous review) to October 2014, with no language or other restrictions. Trial registers (controlled-trials.com and clinicaltrials.gov) were also checked, in addition to reference lists of all eligible studies and other published systematic reviews.

Study selection

We included randomised trials (individual or cluster) directly comparing home-based versus centre-based CR. The study population included adults with MI, angina pectoris or heart failure, or who had undergone coronary revascularisation (coronary artery bypass grafting, percutaneous transluminal coronary angioplasty or coronary artery stenting).

Home-based CR was defined as a structured programme with clear objectives for the participants, including monitoring, follow-up visits, letters or telephone calls from staff or at least self-monitoring diaries.[27] Centre-based CR was a supervised group-based programme undertaken in a hospital or community setting (eg, gym or sports centre). We included exercise-only and comprehensive CR programmes.

Studies with one or more of the following outcome measures were included: mortality (cardiac and overall); morbidity (reinfarction, revascularisation or cardiac-related hospitalisation); exercise capacity; modifiable coronary risk factors (ie, smoking, blood lipid levels and blood pressure); HRQoL; adverse events (withdrawal from the trial or exercise programme); health service use or costs; adherence to CR.

Selection of studies involved the initial screening of titles and abstracts, followed by an assessment of the full-text reports of all potentially relevant trials. Two authors (RST, SGD or RJN) independently assessed trials for inclusion and where there was a disagreement, the opinion of a third author (RST, SGD or RJN) was sought.

Data extraction and risk of bias assessment

The following information categories were extracted: study design, participants (baseline characteristics), details of the intervention (including type, frequency, duration and intensity of exercise training and nature of co-interventions), length of follow-up and outcome results. We assessed study risk of bias using the Cochrane standard criteria[28] (random sequence generation and allocation concealment, dropouts and withdrawals, outcome blinding, and selective reporting) and also balance of groups at baseline and use of intention-to-treat analysis. Data extraction and risk of bias assessment was carried out by a single reviewer (RJN) and checked by a second reviewer (SGD or RST). Where necessary, authors of included studies were contacted for further information. This included clarification of issues of study design to inform risk of bias assessment and outcomes (eg, missing SDs).

Data analysis

Data were analysed in accordance with the Cochrane Handbook.[28] For dichotomous variables, relative risks (RRs) and 95% CIs were calculated for each outcome, and for continuous variables, mean differences (MDs) and 95% CIs were calculated. Where differences between groups for each individual trial were not reported, we calculated p values for the differences.

We explored heterogeneity among the included studies qualitatively (by comparing the study characteristics) and quantitatively (using the χ^2 test of

heterogeneity and I^2 statistic). Where appropriate, an overall estimate of treatment effect was obtained by combining the results from included studies for each outcome. We employed a random-effects model where there was formal evidence of statistical heterogeneity (I^2>50%). For outcomes with lower levels of statistical heterogeneity, we applied both fixed and random models, reporting fixed-effects results unless there was a difference in statistical inference, where we reported the most conservative random-effects model.

Given the variety of outcome measures reported for exercise capacity, to allow us to pool findings across studies, between-group results for each study were expressed as a standardised MD (SMD). Miller *et al*[29] included subgroups by duration of the intervention (11 or 26 weeks) and Gordon *et al*[30] compared two home-based exercise groups with a centre-based programme. For these two studies, outcome results were reported separately for each comparison. Given the small number of studies, it was not possible to assess potential small study effects and publication bias using funnel plots and Egger tests[31] with the exception of the outcome of exercise capacity. We undertook two subgroup analyses for exercise capacity: (1) comparison of trials of patients with heart failure versus other post-MI/revascularisation and (2) comparison of trials published before the year 2000 vs 2000 or later (to assess the impact of older trials in relation to advancement of medical technology, medications and interventional cardiology). Analyses were conducted using RevMan V.5.2.

RESULTS

Study selection

The previous Cochrane review provided 12 included studies (22 publications; JM Bell. A comparison of a multi-disciplinary home based cardiac rehabilitation programme with comprehensive conventional rehabilitation in post-myocardial infarction patients. [Thesis submitted to the University of London for the degree of Doctor of Philosophy]. 1998).[29 30 32–40] Our updated searches produced a total of 12 949 titles from which an additional five studies (six publications) were included.[23–25 41 42] Outcomes of one previously included trial with a longer follow-up (18 months and 6 years postrandomisation) were also identified.[32 43] The study selection process is summarised in figure 1. Excluded studies and reasons for exclusion are shown in online supplementary table A.

The 17 studies of home-based versus centre-based CR included a total of 2172 patients in 10 countries from across four continents (see table 1). Most studies reported outcomes up to 12 months postrandomisation; three studies also reported a longer term follow-up.[32 36 38]

The CR programmes differed considerably between studies in terms of duration (range 1.5–6 months), frequency (one to five sessions per week) and length (20–60 min per session). Eleven studies compared comprehensive programmes (ie, exercise plus education and/or psychological management) while six reported only an exercise intervention.[23 24 29 35 37 40] Most programmes used individually tailored exercise prescriptions, making it difficult to precisely quantify the amount of exercise undertaken. Almost all home-based programmes were based on walking with intermittent support from a nurse or exercise specialist, while centre-based programmes typically provided a supervised cycle and treadmill exercise (see online supplementary table B).

Of the 13 studies that recruited patients following acute MI or coronary revascularisation, 12 of these included patients classed as 'low' or 'moderate' risk as defined by the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) guidelines for CR

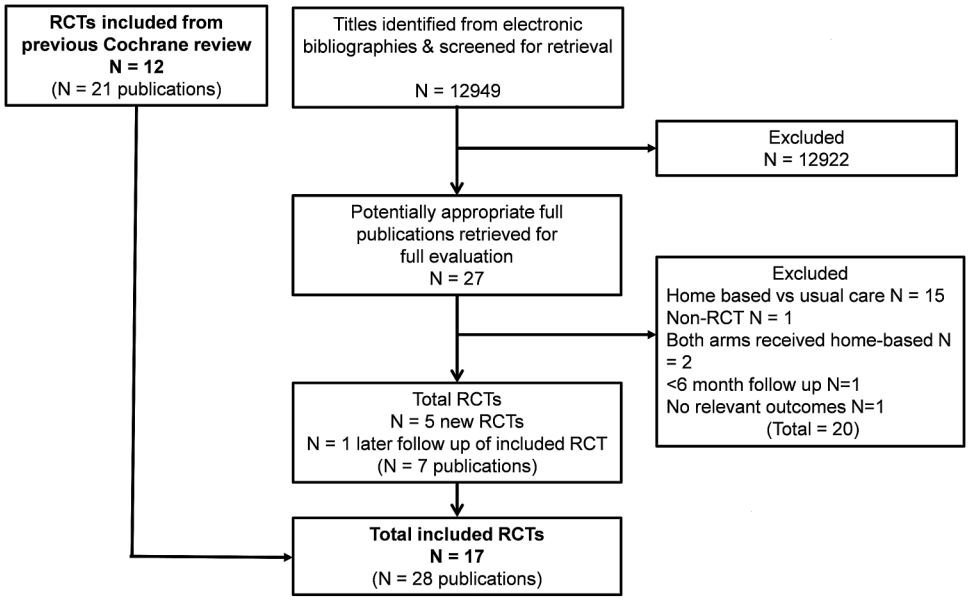

Figure 1 Summary of study selection process.RCT, randomised controlled trial.

Table 1 Summary of included studies

Study	Participants (number and diagnosis)	Interventions	Outcomes	Follow-up	Subgroup analyses	Country/ setting
Arthur *et al*[32]	242 post-CABG surgery	Home-based vs centre-based	*Primary*: exercise capacity (METs). *Secondary*: HRQoL (SF-36), cardiac morbidity, mortality	6 and 18 months and 6 years postrandomisation	None	Canada, single centre
Bell (JM Bell. Thesis submitted to the University of London for the degree of Doctor of Philosophy. 1998)	252 post-MI	Home-based (Heart Manual) vs centre-based	*Primary*: exercise capacity (METs) *Secondary*: total cholesterol, systolic blood pressure, HRQoL (NHP), smoking, mortality, readmission rate, use of primary care services	16 and 48 weeks postrandomisation (20 and 50 weeks post-MI)	None	UK, 5 district hospitals
Carlson *et al*[33]	80 coronary artery bypass, angioplasty, MI, angiographically confirmed CHD	Home-based vs centre-based	*Primary*: peak functional capacity (METs), LDL cholesterol *Secondary*: total cholesterol, HDL cholesterol, triglycerides, blood pressure, cardiovascular medications, costs, adherence (exercise sessions attended)	6 months postrandomisation	None	USA, single hospital centre
Cowie *et al*[23]	60 NYHA class II/III patients with post-HF	Home-based vs centre-based vs usual care control	Exercise capacity (shuttle walk test), HFQoL (SF-36 and MLHFQ)*	8 weeks	None	UK, single centre
Dalal *et al*[34]	104 post-MI	Home-based (Heart Manual) vs centre-based	*Primary*: quality of life (MacNew questionnaire), total cholesterol *Secondary*: exercise capacity (METs), self-reported smoking, cardiovascular morbidity, mortality, secondary prevention medication use	9 months postrandomisation	None	UK, single centre
Daskapan *et al*[35]	29 patients with HF	Home-based vs centre-based	Exercise capacity (mL/kg/min), resting blood pressure, systolic and diastolic blood pressure, adherence, dropouts, mortality*	12 weeks postrandomisation	None	Turkey, single centre
Gordon *et al*[30]	155 coronary artery disease (MI and/or CABG and/or PTCA and/or chronic stable angina)	Supervised home vs community home vs centre-based	Maximal oxygen uptake, blood pressure, fasting serum lipids, self-reported smoking status, rehospitalisation, adherence (completion of appointments)*	12 weeks postrandomisation	Changes reported for all patients and for patients with baseline values defined as abnormal	USA, single centre

Continued

Table 1 Continued

Study	Participants (number and diagnosis)	Interventions	Outcomes	Follow-up	Subgroup analyses	Country/ setting
Jolly *et al*[36]	525 patients with post-MI, post-PTCA and post-CABG	Home-based (Heart Manual) vs centre-based	*Primary*: serum cholesterol, total cholesterol, HDL cholesterol, blood pressure, exercise capacity (ISWT), smoking (cotinine-validated) *Secondary*: quality of life (EQ-5D), health service usage (hospital readmissions, primary care visits, medication), mortality, cardiovascular events, costs	6, 12 and 24 months	Yes—'interaction terms between these factors (diagnosis (MI/ revascularisation), age, sex and ethnicity) and rehabilitation setting were included to investigate possible differences in treatment effect between subgroups of patients'.	UK, 4 hospital centres
Karapolat *et al*[24]	74 patients with HF	Home-based vs centre-based	Exercise capacity, quality of life (SF-36)*	8 weeks	None	Turkey, single centre
Kassaian *et al*[37]	125 patients with post-MI and/or post-CABG	Home-based vs centre-based	Systolic and diastolic blood pressure, heart rate (all resting and submaximal), functional capacity (METs), BMI, cholesterol (total, LDL, HDL, triglyceride)*	12 weeks postrandomisation	Comparison of functional capacity, submaximal systolic blood pressure, diastolic blood pressure, and heart rate in patients with left ventricular dysfunction vs good function	Iran, single centre
Marchionni *et al*[38]	180 patients with post-MI	Home-based vs centre-based	*Primary*: TWC *Secondary*: HRQoL (SIP), mortality, morbidity (cardiovascular events), healthcare usage (medical visits, rehospitalisations), costs, adherence (number of completed training sessions)	2, 8 and 14 months postrandomisation	Subgroup analysis by age (years)—middle-aged (45–65), old (65–75), very old (>75)	Italy, single hospital centre
Miller *et al*[29]	127 patients with post-MI	Home-based vs centre-based	Exercise capacity, mortality, cardiovascular morbidity*	23 weeks postrandomisation	Results reported according to 2 subgroups—brief vs extended exercise training	USA, single hospital centre
Moholdt *et al*[41]	30 patients with post-CABG	Home-based vs centre-based (residential rehabilitation)	*Primary*: peak oxygen consumption *Secondary*: HRQoL, cholesterol (total, HDL and triglycerides)	6 months postrandomisation	None	Norway, single hospital centre
Oerkild *et al*[42]	75 coronary heart disease (acute MI, PTCA or CABG)	Home-based vs centre-based	*Primary*: exercise capacity (VO_2 and 6MWT) *Secondary*: systolic and diastolic blood pressure, cholesterol (total, HDL and LDL), smoking, HRQoL (SF-12)	3 and 12 months	None	Denmark, single centre

Continued

Table 1 Continued

Study	Participants (number and diagnosis)	Interventions	Outcomes	Follow-up	Subgroup analyses	Country/ setting
Piotrowicz *et al*[25]	152 patients with HF (NYHA class II and III)	Home-based (telemonitored) vs centre-based (outpatient)	Exercise capacity (6MWT), quality of life (SF-36), mortality, hospitalisation*	8 weeks	None	Poland, single centre
Sparks *et al*[39]	20 post-MI, PTCA or CABG	Home-based vs centre-based	Exercise capacity (peak VO_2 max), adherence (compliance with exercise), safety (dropout)*	12 weeks postrandomisation	None	USA, single hospital centre
Wu *et al*[40]	36 patients with post-CABG	Home-based vs centre-based	Exercise capacity (METs)*	12 weeks postrandomisation	None	Taiwan (China), single centre

*Primary and secondary outcomes not distinguished.
6MWT, 6 min walk test; BMI, body mass index; CABG, coronary artery bypass graft; CHD, coronary heart disease; HDL, high-density lipoprotein; HF, heart failure; HRQoL, health-related quality of life; LDL, low-density lipoprotein; MI, myocardial infarction; MET, metabolic equivalent; MLHFQ, Minnesota Living with Heart Failure Questionnaire; NHP, Nottingham Health Profile; NYHA, New York Heart Association; PTCA, percutaneous transluminal coronary angioplasty; SF-12, 12-item Short Form Health Survey; SF-36, 36-item Short Form Health Survey SIP, Sickness Impact Profile; TWC, total work capacity.

and secondary prevention programmes,[44] excluding those with significant arrhythmias or comorbidities. The only exception was the study by Oerkild *et al*[42] where classification was not possible due to lack of information. Four studies included those with New York Heart Association (NYHA) class II or III heart failure (n=315).[23–25 35]

Risk of bias

Several studies did not report sufficient detail to fully assess their potential risk of bias (see figure 2). Details of selection bias (random allocation sequence generation and concealment) were in particular poorly

Figure 2 Summary of risk of bias assessment (authors' judgements about each methodological quality item for each included study).

reported. However, only two studies presented objective evidence of imbalances in baseline patient characteristics.[23 32] Given the nature of the CR intervention, it is not possible to blind the patients or clinicians to group allocation; in such situations, blinding outcome assessors to knowledge of allocation is probably of greater importance. Only seven studies stated that they took measures to blind outcome assessment (JM Bell. Thesis submitted to the University of London for the degree of Doctor of Philosophy. 1998).[23 32 34 36 38 40] Although the type of analysis was often not stated, all studies appeared to undertake an intention-to-treat analysis (ie, groups were compared according to initial random allocation). Loss to follow-up or dropout appeared to vary considerably across studies and was often asymmetric between home-based and centre-based groups. Although it was difficult to quantify the precise level of CR intervention delivered (due to the individually tailored nature of many programmes), the intensity of the rehabilitation programme seemed to differ substantially between the home-based and centre-based arms. The majority of trials were judged to be of low risk of bias in terms of selective reporting and whether groups received the same co-interventions.

Effects of interventions

Clinical events: mortality and morbidity

All-cause mortality up to 1 year of follow-up was reported in 8 of the 17 studies (JM Bell. Thesis submitted to the University of London for the degree of Doctor of Philosophy. 1998).[25 29 34–36 41 42] A pooled analysis of these studies (excluding Miller *et al*,[29] who reported no deaths) found no difference in mortality at 3–12 months of follow-up between the home-based and centre-based CR groups (see online supplementary figure A). The study of Jolly *et al*[36] found no significant between-group difference at 24 months.

Only four studies reported cardiac events. Dalal *et al*[34] and Jolly *et al*[36] found no significant difference in coronary revascularisation or recurrent MI events between home-based and centre-based CR, and Piotrowicz *et al*[25] reported no heart failure-related admissions in either group. Oerkild *et al*[42] did not report numbers of events but stated that there were no between-group differences in the number and length of admissions and adverse events including MI, progressive angina, decompensated congestive heart failure, severe bleeding, new malignant disease and performance of percutaneous coronary intervention. In the 6-year follow-up of the study by Arthur *et al*,[32 43] the total number of hospitalisations (cardiac and non-cardiac) was greater in centre-based patients with CR than in the home-based group (79 vs 42, p<0.0001).

Exercise capacity

All 17 included studies reported on exercise capacity in the short term (≤12 months' follow-up) and 3 reported longer term data (>12 months).[32 36 38] Measures of exercise capacity included peak oxygen uptake, walking distance and workload on a static cycle.

Pooled analysis of all studies showed no difference in short-term exercise capacity between the home-based and centre-based CR (random-effects SMD −0.10, 95% CI −0.29 to 0.08, I^2 72%; see table 2 and figure 3A). Similarly, pooled analysis of the studies with >12 months' follow-up showed that there was no evidence of an overall difference in exercise capacity between the two groups in the longer term (fixed-effects SMD 0.11, 95% CI −0.01 to 0.23, I^2 0%; see table 2 and figure 3B). Arthur *et al*[32] found that mean peak oxygen consumption at 6-year follow-up was higher (p=0.01) in the home-based CR group (1543 mL/min) than for those who received centre-based CR (1412 mL/min).

There was no evidence of subgroup difference in the difference in exercise capacity between home-based and centre-based CR comparing two groups of trials: (1) trials in heart failure versus trials in post-MI/revascularisation (subgroup p=0.74); (2) trials published before 2000 versus trials in 2000 or later (subgroup p=0.59).

Modifiable cardiovascular risk factors

Eight trials assessed systolic and diastolic blood pressure[30 33–37 42] or systolic blood pressure alone (JM Bell. Thesis submitted to the University of London for the degree of Doctor of Philosophy. 1998), with absolute values at follow-up reported by all but two studies[30 42] which reported change from baseline instead. Pooled analysis showed no difference in systolic blood pressure between home-based and centre-based patients with CR at follow-up (random-effects MD 0.2 mm Hg, 95% CI −3.4 to 3.8, I^2 65%; see table 2, online supplementary figure B). Diastolic blood pressure was slightly lower following centre-based CR compared with home-based CR (fixed-effects MD<−1.9 mm Hg, 95% CI −0.8 to −3.0, I^2 37%; p=0.009; see table 2, online supplementary figure C). At 24 months' follow-up, Jolly *et al*[36] reported no difference in either systolic (MD 0.85 mm Hg, 95% CI −2.5 to 4.2) or diastolic (MD 0.8 mm Hg, 95% CI −1.1 to 2.6) blood pressure between the home-based and centre-based groups.

Of the eight trials reporting data on blood lipids, all reported total cholesterol values (JM Bell. Thesis submitted to the University of London for the degree of Doctor of Philosophy. 1998),[30 33 34 36 37 41 42] six reported high-density lipoprotein (HDL) concentrations[30 33 36 37 41 42] and four reported low-density lipoprotein (LDL) cholesterol and triglycerides.[30 33 37 42] Meta-analysis found no evidence of a difference between the home-based and centre-based groups in terms of total cholesterol (random-effects MD −0.07 mmol/L, 95% CI −0.24 to 0.11, I^2 62%), LDL (random-effects MD −0.06 mmol/L, 95% CI −0.27 to 0.15, I^2 62%) or triglyceride (random-effects MD −0.16 mmol/L, 95% CI −0.38 to 0.07, I^2 47%) concentrations at 3–12 months' follow-up (see table 2, online supplementary figures D, F and G). There was some evidence of a lower HDL

Table 2 Summary of the effects of home-based versus centre-based cardiac rehabilitation

Outcome or subgroup	Number of studies	Number of participants	Summary estimate and model	Effect estimate (95% CI) with p values where significant	Heterogeneity χ^2	d.f.	p Value	I^2 (%)
Exercise capacity								
≤12-month follow-up	19	1876	Standard mean difference, random-effects model	−0.10 (−0.29 to 0.08)	63.30	18	<0.00001	72
12–24-month follow-up	3	1074	Standard mean difference, fixed-effects model	0.11 (−0.01 to 0.23)	0.97	2	0.62	0
Blood pressure (mm Hg) at 3–12-month follow-up								
Systolic	9	1117	Mean difference, random-effects model	0.19 (−3.37 to 3.75)	23.07	8	0.003	65
Diastolic	8	991	Mean difference, fixed-effects model	−1.86 (−2.95 to −0.76) lower in centre-based group (p=0.009)	11.12	7	0.13	37
Cholesterol (mmol/L) at 3–12-month follow-up								
Total	9	1109	Mean difference, random-effects model	−0.07 (−0.24 to 0.11)	20.98	8	0.007	62
HDL	7	883	Mean difference, fixed-effects model	−0.07 (−0.11 to −0.03) lower in centre-based group (p=0.001)	10.49	6	0.11	43
LDL	5	388	Mean difference, random-effects model	−0.06 (−0.27 to 0.15)	10.60	4	0.03	62
Triglycerides	5	354	Mean difference, random-effects model	−0.16 (−0.38 to 0.07)	7.59	4	0.11	47
Smoking (3–12 months)	6	986	Relative risk, fixed-effects model	0.98 (0.79 to 1.21)	4.48	5	0.48	0
Completers	18	1984	Risk ratio, fixed-effects model	1.04 (1.01 to 1.07) higher completion in home-based group (p=0.009)	30.26	17	0.02	44
Mortality	7	1166	Relative risk, fixed-effects model	0.79 (0.43 to 1.47)	1.60	5	0.90	0

HDL, high-density lipoprotein; LDL, low-density lipoprotein.

concentration following centre-based CR (random-effects MD −0.07 mmol/L, 95% CI −0.03 to −0.11, I^2 43%; p=0.001; see table 2, online supplementary figure E), but the difference in HDL level was not sustained at 24 months' follow-up.[36]

A consistent reduction in self-reported smoking behaviour was found in the five studies that reported this outcome for the home-based and centre-based CR arms (JM Bell. Thesis submitted to the University of London for the degree of Doctor of Philosophy. 1998).[30 34 36 42] The proportion of smokers at follow-up in the centre-based group was similar to that in the home-based group after 3–12 months (fixed-effects RR 0.98, 95% CI 0.79 to 1.21, I^2 0%; see table 2, online supplementary figure H) and 24 months (RR=1.16, 95% CI 0.58 to 33.3).[36]

Health-related quality of life

Pooling of HRQoL outcomes was considered inappropriate due to the wide variation of measures used and instead results were compared across studies and tabulated (see table 3). Ten studies reported validated HRQoL measures including four generic measures (EQ-5D, Nottingham Health Profile, 36-item Short Form Health Survey (SF-36) and Sickness Impact Profile) and one disease-specific instrument (MacNew). From individual findings, there was no strong evidence of differences in overall HRQoL outcomes or domain scores at follow-up between home-based and centre-based CR. All studies reported improvements in HRQoL from baseline to follow-up, with the exception of two studies that used the EQ-5D where there were no changes in either the home-based or centre-based groups.[34 36]

Withdrawals and adherence

There was inconsistent reporting of dropout rates from the intervention, and reasons for withdrawal were often unclear. Using the number of completers (ie, the number of patients with outcome data at follow-up), we found some evidence of a small increase in the completion rate in the home-based compared with the centre-

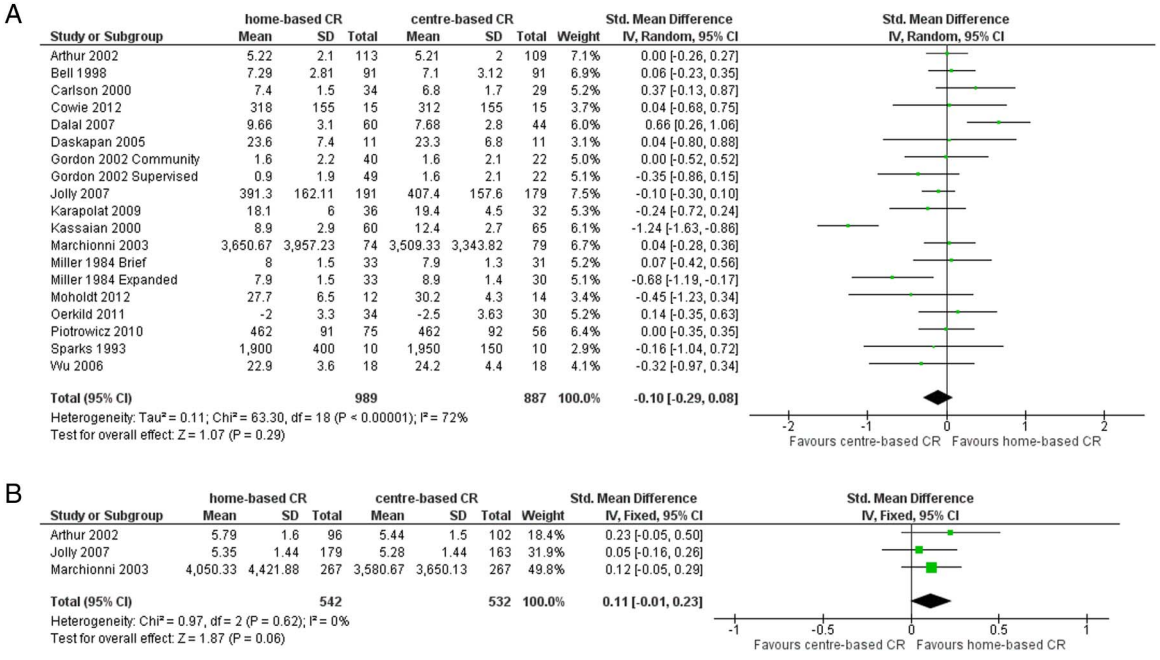

Figure 3 (A) Exercise capacity with home-based and centre-based CR at ≤12 months' follow-up. (B) Exercise capacity with home-based and centre-based CR at 12–24 months' follow-up. CR, cardiac rehabilitation.

based programmes (fixed-effects RR 1.04, 95% CI 1.01 to 1.07, I^2 44%; p=0.009).

All except four trials (JM Bell. Thesis submitted to the University of London for the degree of Doctor of Philosophy. 1998)[35 37 40] reported adherence to the rehabilitation programme for the duration of the study. Substantial variation in the definition and measures of adherence was seen across studies, so results were not pooled. Seven studies[23 24 29 30 33 34 36] reported no significant difference in adherence between the home-based and centre-based rehabilitation groups, whereas three studies found evidence of higher adherence in patients undertaking home-based CR[25 32 38] (see online supplementary table C and figure I).

Healthcare costs and usage

Costs of the intervention in home-based and centre-based settings were reported by four studies and are shown in table 4. In three of the four studies, healthcare costs associated with CR were lower for the home-based than the centre-based programmes,[33 34 38] but only significantly lower in one study.[34] Jolly *et al*[36] found home-based CR to be more expensive than centre-based CR. However, when patients' costs were included, no significant difference in overall costs between home-based and centre-based interventions was seen.

No significant differences were observed between the home-based and centre-based groups in terms of healthcare resource use. Eight studies reported measures of healthcare usage including hospital readmissions, primary care consultations and use of secondary care medication (see table 5).

Small study bias

There was no evidence of funnel plot asymmetry for exercise capacity (Egger test p=0.71).

DISCUSSION

We conducted an updated systematic review and meta-analysis comparing the effects of home-based and supervised centre-based CR. Our study shows no consistent evidence to support differences in patient outcomes for those receiving home-based or centre-based rehabilitation in either the short term (≤12 months) or longer term (>12 months). Outcomes considered included exercise capacity, modifiable risk factors (blood pressure, blood lipid concentrations and smoking), HRQoL and cardiac events (mortality, coronary revascularisation and hospital readmissions).

The findings of this updated review are in agreement with those of the previous Cochrane review comparing home-based versus centre-based rehabilitation.[21] However, importantly, this review now includes data from four trials in 315 patients with heart failure,[23–25 35] supplementing the evidence base in the previous review that was largely in patients following MI and coronary revascularisation. Our results are consistent with the body of evidence that shows centre-based and home-based delivered disease management to provide similar benefits to cardiac populations. For example, the recent WHICH? trial conducted in Australia indicated that a home-based heart failure management programme was equally effective in terms of outcome (improved HRQoL

Table 3 Comparison of HRQoL outcomes at follow-up for home-based and centre-based cardiac rehabilitation

Trial Author (year)	Follow-up	HRQoL measure	Outcome values at follow-up or mean difference (95% CI) Mean (SD) Home vs centre, between group p value	Between-group difference
Bell (1998)	10.5 months	Nottingham Health Profile		
		Energy	18.6 (28.4) vs 17.3 (30.7) p=0.78*	Home=centre
		Pain	6.6 (15.3) vs 7.4 (15.5) p=0.74*	Home=centre
		Emotional reactions	6.6 (15.3) vs 7.4 (15.5) p=0.74*	Home=centre
		Sleep	6.6 (15.3) vs 16.9 (22.8) p=0.0007*	Home<centre
		Social isolation	3.7 (13.6) vs 6.7 (15.0) p=0.18*	Home=centre
		Physical mobility	6.9 (13.5) vs 9.1 (15.9) p=0.33*	Home=centre
Arthur *et al* (2002)/ Smith *et al* (2004)[60]	6 months	SF-36 PCS	51.2 (6.4) vs 48.6 (7.1) p=0.003*	Home>centre
		MCS	53.5 (6.4) vs 52.0 (8.1) p=0.13*	Home=centre
	18 months	SF-36 PCS	48.3 (11.7) vs 47.6 (11.7) p=0.67*	Home=Centre
		MCS	53.0 (10.9) vs 50.2 (10.9) p=0.07*	Home=centre
Cowie *et al* (2012)	3 months	SF-36 PCS	34.01 (11.04) vs 31.33 (7.97) p=0.82	Home=centre
		MCS	44.44 (12.23) vs 48.25 (11.21) p=0.04	Home<centre
		MLWHF total	37 (NR) vs 32 (NR) p=0.18	Home=centre
		Physical	21 (NR) vs 19 (NR) p=0.31	Home=centre
		Emotional	7 (NR) vs 7 (NR) p=0.13	Home=centre
Marchionni *et al* (2003)	2 months	Sickness Impact Profile	2.83 (14.5) vs 4.71 (11.1) p=0.09*	Home=centre
	8 months		2.83 (14.5) vs 3.40 (11.1) p=0.61*	Home=centre
	14 months		2.00 (8.3) vs 3.70 (11.8) p=0.06*	Home=centre
Dalal *et al* (2007)/ Taylor *et al* (2007)[61]	9 months	MacNew Global Score	5.61 (1.14) vs 5.54 (1.10) p=0.71	Home=centre
		EQ-5D	0.74 (0.04) vs 0.78 (0.04) p=0.57	Home=centre
Jolly *et al* (2007)	6 months	EQ-5D	0.74 (0.26) vs 0.76 (0.23) p=0.37	Home=centre
		SF-12 PCS	42.28 (10.9) vs 42.56 (10.8) p=0.8	Home=centre
		MCS	49.19 (10.1) vs 50.33 (9.6) p=0.3	Home=centre
	12 months	EQ-5D	0.74 (0.27) vs 0.76 (0.23) p=0.52*	Home=centre
	24 months	EQ-5D	0.73 (0.29) vs 0.75 (0.26) p=0.39*	Home=centre
Karapolat *et al* (2009)	8 weeks	SF-36		
		Physical function	59.39 (25.35) vs 69.57 (20.94), p=0.08*	Home=centre
		Physical role	39.81 (41.75) vs 48.21 (45.10) p=0.43*	Home=centre
		Bodily pain	62.42 (30.45) vs 74.23 (19.66) p=0.07*	Home=centre
		General health	47.25 (23.42) vs 53.98 (25.00) p=0.33*	Home=centre
		Vitality	66.67 (19.82) vs 69.81 (17.41) p=0.49*	Home=centre
		Social function	65.33 (25.60) vs 69.33 (25.14) p=0.52*	Home=centre
		Emotional role	44.74 (39.77) vs 37.16 (39.24) p=0.44*	Home=centre
		Mental health	64.67 (19.04) vs 70.52 (20.37) p=0.22*	Home=centre
Moholdt *et al* (2012)	6 months	MacNew		
		Emotional domain	1.2 (0.2) vs 1.4 (0.2) p>0.05	Home=centre
		Physical domain	1.4 (0.7) vs 1.6 (1.1) p>0.05	Home=centre
		Social domain	4.3 (0.7) vs 4.3 (1.0) p>0.05	Home=centre
Oerkild *et al* (2011)	3 months	SF-36 PCS	1.4 (−1.5 to 4.3) vs, 0.5 (−2.4 to 3.4), p>0.05	Home=centre
		SF-36 MCS	0.8 (−2.6 to 4.3) vs −0.2 (−3.6 to 3.4), p>0.05	Home=centre
	6 months	SF-36 PCS	1.0 (−1.6 to 3.6) vs 1.2 (−1.4 to 3.8), p>0.05	Home=centre
		SF-36 MCS	2.3 (−1.1 to 5.7) vs 2.6 (−0.9 to −6.0), p>0.05	Home=centre
Piotrowicz *et al* (2010)	8 weeks	SF-36 total	70.5 (25.4) vs 69.2 (26.4) (p>0.05)	Home=centre

*p Value calculated by authors of this report based on an independent two-group t-test.
Home=centre: no statistically significant difference (p≥0.05) in HRQoL between home-based and centre-based groups at follow-up.
Home>centre: statistically significant (p<0.05) higher HRQoL in home-based versus centre-based groups at follow-up.
Home<centre: statistically significant (p<0.05) lower HRQoL in home-based versus centre-based groups at follow-up.
HRQoL, health-related quality of life; MCS, mental component score; MLWHF, Minnesota Living With Heart Failure; NR, not reported; PCS, physical component score; SF-12, 12-item Short Form Health Survey; SF-36, Short Form (36) Health Survey.

Table 4 Summary of costs for home-based and centre-based groups

Trial Author (year)	Currency Year of costs Follow-up	Cardiac rehabilitation programme cost (per patient)	Programme costs considered	Total healthcare cost (per patient)	Additional healthcare costs considered	Comments
Carlson *et al* (2000)	US$ Not reported 6 months	Home: mean 1519 Centre: mean 2349	Staff, ECG monitoring	Not reported		
Marchionni *et al* (2003)	US$ 2000 14 months	Home: mean 1650 Centre: mean 8841	Not reported	Home: 21 298 Centre: 13 246	Not reported	
Dalal *et al* 2007	UK£ 2002–2003 9 months	Home: mean 170 (SD 8) Centre: mean 200 (SD 3) Difference: mean 30 95% CI −45 to −12 p<0.0001	Staff, exercise equipment, staff travel	Home: mean 3279 (SD 374) Centre: mean 3201 (SD 443) Difference: mean 78 95% CI −1103 to 1191 p=0.894	Rehospitalisations, revascularisations, secondary preventive medication, investigations, primary care consultations	
Jolly *et al* 2007	UK£ 2003 24 months	Home: mean 198 95% CI 189 to 209 Centre: mean 157 95% CI 139 to 175 p<0.05	Staff, telephone consultations, staff travel	Not reported		With inclusion of patient costs (travel and time), the societal costs of home-based and centre-based cardiac rehabilitation were not significantly different.

and reduced level of hospitalisation) and was associated with lower healthcare costs compared with an equivalent clinic-based programme.[45 46] Given this evidence for disease management programmes, it has been proposed that what matters may be the quality, structure and availability of the follow-up rather than the location of follow-up per se.[47]

Despite level 1A evidence for the recommendation of CR,[10–15] the uptake of CR in the UK and internationally remains suboptimal, with participation rates ranging from 20% to 50%.[7 20 48–50] Recent commentaries have therefore called for alternative ways of providing CR to improve participation.[51] The choice of a home-based CR intervention provides the opportunity to increase access and uptake.[34 52]

The finding of this review of an absence of evidence of important differences in patient outcomes and healthcare costs between centre-based and home-based CR supports the further provision of home-based CR programmes. Self-management and collaboration with caregivers can also improve uptake and outcomes.[53–55] The main approach to CR delivery in most countries is a supervised centre-based programme, which usually takes place in a hospital, university or community setting. However, the evidence of this review supports national and international clinical guidelines for the management of heart failure, explicitly recommending home-based CR alongside more traditional supervised centre-based CR programmes. The availability of home-based programmes could increase participation in CR by allowing those unable to attend centre-based CR sessions due to problems involving access and lifestyle commitments to take part in sessions that are individually tailored to suit their needs and fit around their life. This would overcome current capacity constraints within centre-based programmes. Home-based programmes should, as centre-based, be comprehensive in nature (ie, provide education and psychological support in addition to exercise training) and include health professional support such as regular telephone calls and/or home visits, particularly in the early stages of the programme. Providing patients with the choice of centre-based or home-based CR (or a combination of the two) according to their preferences may increase both uptake and adherence. Patients recovering from MI, coronary revascularisation and heart failure should be able to benefit from CR, which can prevent premature cardiovascular death, reduce hospital admissions and improve HRQoL, something that has never been accomplished for the majority of patients.[8 56–59]

Table 5 Summary of healthcare resource use in home-based and centre-based cardiac rehabilitation by months of follow-up

Trial Author (year)	Dalal *et al* (2007)	Gordon *et al* (2002)	Bell (1998)		Carlson *et al* (2000)	Marchionni *et al* (2003)	Jolly *et al* (2007)		Moholdt *et al* (2012)	Oerkild *et al* (2011)
Follow-up	9 months	3 months	0–6 months	6–12 months	6 months	14 months	12 months	24 months	6 months	12 months
Rehospitalisations									Not reported	Number and length of admissions same between groups
N patient (%)	Home 9/60 (15%) Centre 6/44 (14%) p=0.845		Home 21/90 (23%) Centre 19/88 (22%) p=0.78#	13/89 (15%) 12/84 (14%) p=0.95#						
Mean (SD)	Home 2.2 (0.9)† Centre 1.2 (0.6) p=0.383					Home 0.46 (SE 0.1) Centre 0.33 (SE 0.1) p=0.49	Home 0.08 (0.34) Centre 0.12 (0.41) p=0.3	Home 0.20 (0.45) Centre 0.26 (0.57) p=0.3		
Primary care consultations									Not reported	Not reported
Mean (SD)	Home 6.3 (0.6) Centre 7.0 (0.9) p=0.514		Home 6.6 (3.6)* Centre 6.6 (4.1) p=1.00#	5.4 (4.1) 4.6 (3.7) p=0.19#			Home 0.65 (1.14) Centre 0.72 (1.54) p=0.8	Home 0.53 (1.14) Centre 0.66 (1.42) p=0.7		
Secondary prevention medication										Not reported
N patients (%)	Home 31/49 (63%)	Home 36/97 (37%)			Home 19/38		Home 169 (72.2%)	Home 161 (71.6%)	Home: 8/14 (57%)	
Beta-blockers	Centre 24/34 (71%) p=0.49	Centre 17/45 (38%) NS			Centre 18/42 p=0.52#		Centre 171 (73.4%) p=0.8	Centre 164 (72.2%) p=0.9	Centre: 15/16 (94%) p=0.02*	
ACE inhibitors	Home 30/49 (61%)	Home 25/97 (26%)			Home 4/38		Home 176 (75.2%)*	Home 177 (78.7%)*	Home: 1/14 (7%)	
	Centre 24/33 (73%) p=0.28	Centre 8/45 (18%) NS			Centre 4/42 p=0.88#		Centre 161 (69.1%)* p=0.1	Centre 156 (68.7%)* p=0.02	Centre: 0/16 (0%) p=0.28*	
Statins	Home 48/49 (98%)*	Home 73/97 (75%)			Home 5/38		Home 216 (92.3%)**	Home 195 (86.7%)**	Home: 6/14 (43%)	
	Centre 30/35 (88%)* p=0.18	Centre 33/45 (73%) NS			Centre 8/42 p=0.47#		Centre 221 (94.8%)** p=0.3	Centre 206 (90.7%)** p=0.2	Centre: 2/16 (13%) p=0.07*	
Antiplatelets	Home 46/49 (94%)	Home 94/97 (97%)*			Home 15/38		Home 227 (97.0%)†	Home 214 (95.1%)†	Home: 14/14 (100%)	
	Centre 30/35 (86%) p=0.21	Centre 45/45 (100%)* NS			Centre 20/42 p=0.54#		Centre 226 (97.0%)† p=1.0	Centre 220 (96.9%)† p=0.3	Centre: 14/16 (100%) p=0.18*	
Comments	†number of nights *lipid lowering drugs	*antiplatelets & anticoagulants NS: not statistically significant	*GP consultations		#P-value calculated by authors of the present report	SE: standard error	*angiotensin-converting-enzyme inhibitor or Angiotensin II receptor antagonist **cholesterol-lowering drugs †Aspirin or antiplatelet drugs	*angiotensin-converting-enzyme inhibitor or Angiotensin II receptor antagonist **cholesterol-lowering drugs †Aspirin or antiplatelet drugs	*p Value calculated by authors of the present report.	

Figures are means (SD or 95% CI).
GP, general practitioner; NS, not statistically significant; SD, standard deviation.

Limitations

The generally poor level of reporting in the included studies made it difficult to assess their methodological quality and thereby judge their risk of bias. However, we did find some improvements in the quality of reporting in recently published studies. Details of interventions were often poorly reported, so it was also unclear whether the CR programmes delivered in the included studies meet the service quality recommendations such as those of the UK CR standards.[7] Our review is limited by statistical heterogeneity in a number of outcomes across trials, which may reflect the variety of centre-based interventions. In addition, most studies were of relatively short duration; only three trials reported outcomes beyond 12 months of follow-up.[32 36 38] Given the variation in outcome measures across trials, we used the SMD. This method assumes that differences in SDs among studies reflect differences in measurement scales and not real differences in variability of study populations.[28] However, this assumption may be problematic in the context of this systematic review where the study populations vary in their indication.

Nevertheless, we believe this to be the most comprehensive review of evidence until now, summarising the results of randomised trials in over 2000 patients.

CONCLUSIONS

Home-based and hospital-based or centre-based CR have similar benefits in terms of clinical events, risk factors and HRQoL outcomes in patients after MI or coronary revascularisation and in those with heart failure. Together with the absence of evidence of differences in healthcare costs, and given the current suboptimal uptake of CR services, these findings strongly support the further roll-out of home-based CR programmes, thus offering patients improved access and choice.

Future research should focus on the long-term effects of home-based versus centre-based CR, and well-reported adequately powered head-to-head randomised studies are needed in patient groups poorly represented in this review, including angina pectoris.

Author affiliations
[1]Department of Research, Development & Innovation, Royal Cornwall, Hospitals NHS Trust, Truro, UK
[2]Institute of Health Research (Primary Care), University of Exeter Medical School, Exeter, Devon, UK
[3]Institute for Applied Health Research, University of Birmingham, Birmingham, UK
[4]Agency for Health Technology Assessment and Tariff System, Warsaw, Poland
[5]Cardiac Rehabilitation, University Hospital Ayr, Ayr, UK
[6]Institute of Bioengineering, School of Engineering and Materials Science, Queen Mary University of London, London, UK

Acknowledgements The authors would like to thank Nicole Martin of the Cochrane Heart Group editorial team for updating the search strategies and running the updated searches.

Contributors All named authors have contributed to the manuscript in compliance with the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. RST and RJN led the design of this review update. Study selection was undertaken by RST and RJN. RST, RJN and SGD undertook the data extraction and risk of bias assessment. RST and RJN undertook the data analysis. SAB undertook the first draft of the paper and all authors commented on draft versions of the paper. All authors have read and approved the final version of the manuscript.

Funding SAB, HMD and RST are supported by the National Institute for Health Research (NIHR) under its Programme Grants for Applied Research Programme (Grant Reference Number RP-PG-1210-12004). RST and SGD are supported by the NIHR Collaboration for Leadership in Applied Health Research and Care South West Peninsula (PenCLAHRC) at the Royal Devon and Exeter National Health Service (NHS) Foundation Trust. KJ is part-funded by the NIHR Collaboration for Leadership in Applied Health Research West Midlands.

Disclaimer The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

Competing interests RST is an author on a number of other Cochrane reviews of cardiac rehabilitation (CR). HMD, RST and KJ are investigators on the REACH-HF programme of research, which is developing and evaluating a home-based CR intervention for people with heart failure and their carers (NIHR PGfAR RP-PG-0611-12004).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The study protocol and study data are available from the corresponding author on request.

REFERENCES

1. World Health Organization (WHO) 2015. WHO Mortality Database: 25 November 2015. http://www.who.int/healthinfo/statistics/mortality_rawdata/en/index.html (accessed 25 May 2016).
2. British Heart Foundation (BHF). Heart statistics. 2015. http://www.bhf.org.uk/research/heart-statistics (accessed 22 Dec 2015).
3. Balady GJ, Williams MA, Ades PA, *et al*, American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee; Council on Clinical Cardiology; Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; American Association of Cardiovascular and Pulmonary Rehabilitation. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. J Cardiopulm Rehabil Prev 2007;27:121–9.
4. Piepoli M, Maugeri FS, Campana M, *et al*. Experience from controlled trials of physical training in chronic heart failure. Protocol and patient factors in effectiveness in the improvement of exercise tolerance. *Eur Heart J* 1998;19:466–75.
5. Piepoli MF, Corrà U, Benzer W, *et al*, Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. Secondary prevention through cardiac rehabilitation: from knowledge to implementation. A position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2010;17:1–17.
6. Corrà U, Giannuzzia P, Adamopoulos S, *et al*, Working Group on Cardiac Rehabilitation and Exercise Physiology of the European Society of Cardiology. Executive summary of the position paper of the Working Group on Cardiac Rehabilitation and Exercise Physiology of the European Society of Cardiology (ESC): core components of cardiac rehabilitation in chronic heart failure. *Eur J Cardiovasc Prev Rehabil* 2005;12:321–5.
7. British Association for Cardiovascular Prevention and Rehabilitation (BACPR). *The BACPR standards and core components for cardiovascular disease prevention and rehabilitation*. 2nd edn. 2012.

http://www.bacpr.com/resources/46c_bacpr_standards_and_core_components_2012.pdf (accessed 14 Oct 2015).
8. Anderson L, Oldridge N, Thompson DR, *et al*. Exercise-based cardiac rehabilitation for coronary heart disease: Cochrane systematic review and meta-analysis. *J Am Coll Cardiol* 2016;67:1–12.
9. Taylor RS, Sagar VA, Davies EJ, *et al*. Exercise-based rehabilitation for heart failure. *Cochrane Database Syst Rev* 2014;(4):CD003331.
10. National Institute for Health and Care Excellence (NICE). *Chronic heart failure. Management of chronic heart failure in adults in primary and secondary care*. NICE Clinical Guideline CG108, 2010.
11. National Institute for Health and Care Excellence (NICE). MI – secondary prevention. Secondary Prevention in Primary and Secondary Care for Patients Following a Myocardial Infarction. NICE Clinical Guideline CG172, 2013.
12. McMurray JV, Adamopoulos S, Anker SD, *et al*, ESC Committee for Practice Guidelines. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012 The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. *Eur Heart J* 2012;33:1787–847.
13. Yancy CW, Jessup M, Bozkurt B, *et al*, American College of Cardiology Foundation; American Heart Association Task Force on Practice Guidelines. 2013 ACCF/AHA Guideline for the management of heart failure. A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2013;62:e147–239.
14. Piepoli MF, Corrà U, Adamopoulos S, *et al*. Secondary prevention in the clinical management of patients with cardiovascular diseases. Core components, standards and outcome measures for referral and delivery: a policy statement from the cardiac rehabilitation section of the European Association for Cardiovascular Prevention & Rehabilitation. Endorsed by the Committee for Practice Guidelines of the European Society of Cardiology. *Eur J Prev Cardiol* 2014;21:664–81.
15. Balady GJ, Ades PA, Bittner VA, *et al*. American Heart Association Science Advisory and Coordinating Committee. Referral, enrolment, and delivery of cardiac rehabilitation/secondary prevention programs at clinical centers and beyond: a presidential advisory from the American Heart Association. *Circulation* 2011;124:2951–60.
16. Dalal HM, Wingham J, Palmer J, *et al*, REACH-HF investigators. Why do so few patients with heart failure participate in cardiac rehabilitation? A cross-sectional survey from England, Wales and Northern Ireland. *BMJ Open* 2012;2:e000787.
17. Karmali KN, Davies P, Taylor F, *et al*. Promoting patient uptake and adherence in cardiac rehabilitation. *Cochrane Database Syst Rev* 2014;(6):CD007131.
18. Beswick AD, Rees K, Griebsch I, *et al*. Provision, uptake and cost of cardiac rehabilitation programmes: improving services to under-represented groups. *Health Technol Assess* 2004;8:iii–iv, ix-x, 1-152.
19. Heart Manual Department 2015. *Heart manual programmes*. Edinburgh: Heart Manual Department, NHS Lothian, 2015. http://www.theheartmanual.com/Programmes (accessed 26 Jan 2016).
20. National Audit of Cardiac Rehabilitation (NACR) 2015. *The National Audit of Cardiac Rehabilitation Annual Statistical Report 2015*. British Heart Foundation. http://www.cardiacrehabilitation.org.uk/docs/NACR%20Annual%20Statistical%20Report%202015.pdf (accessed 4 Jan 2016).
21. Taylor RS, Dalal H, Jolly K, *et al*. Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev* 2010;(1):CD007130.
22. Dalal HM, Zawada A, Jolly K, *et al*. Home based versus centre based cardiac rehabilitation: Cochrane systematic review and meta-analysis. *BMJ* 2010;340:b5631.
23. Cowie A, Thow MK, Granat MH, *et al*. Effects of home versus hospital-based exercise training in chronic heart failure. *Int J Cardiol* 2012;158:296–8.
24. Karapolat H, Demir E, Bozkaya YT, *et al*. Comparison of hospital-based versus home-based exercise training in patients with heart failure: effects on functional capacity, quality of life, psychological symptoms, and hemodynamic parameters. *Clin Res Cardiol* 2009;98:635–42.
25. Piotrowicz E, Baranowski R, Bilinska M, *et al*. A new model of home-based telemonitored cardiac rehabilitation in patients with heart failure: effectiveness, quality of life, and adherence. *Eur J Heart Fail* 2010;12:164–71.
26. Moher D, Liberati A, Tetzlaff J, *et al*. PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
27. Jolly K, Taylor RS, Lip GY. Home-based cardiac rehabilitation compared with centre-based rehabilitation and usual care: a systematic review and meta-analysis. *Int J Cardiol* 2006;111:343–51.
28. Higgins JPT, Green S. eds. *Cochrane handbook for systematic reviews of interventions 5.1.0*. (updated March 2011). The Cochrane Collaboration, 2011. http://www.cochrane.org/training/cochrane-handbook. (accessed 23 Dec 2015).
29. Miller NH, Haskell WL, Berra K, *et al*. Home versus group exercise training for increasing functional capacity after myocardial infarction. *Circulation* 1984;70:645–9.
30. Gordon NF, English CD, Contractor AS, *et al*. Effectiveness of three models for comprehensive cardiovascular disease risk reduction. *Am J Cardiol* 2002;89:1263–8.
31. Egger M, Davey Smith G, Schneiger M, *et al*. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;315:629–34.
32. Arthur HM, Smith KM, Kodis J, *et al*. A controlled trial of hospital versus home-based exercise in cardiac patients. *Med Sci Sports Exerc* 2002;34:1544–50.
33. Carlson JJ, Johnson JA, Franklin BA, *et al*. Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. *Am J Cardiol* 2000;86:17–23.
34. Dalal HM, Evans PH, Campbell JL, *et al*. Home-based versus hospital-based cardiac rehabilitation after myocardial infarction: a randomized trial with preference arms—Cornwall Heart Attack Rehabilitation Management Study (CHARMS). *Int J Cardiol* 2007;119:202–11.
35. Daskapan A, Arikan H, Caglar N, *et al*. Comparison of supervised exercise training and home-based exercise training in chronic heart failure. *Saudi Med J* 2005;26:842–7.
36. Jolly K, Taylor R, Lip GY, *et al*. The Birmingham Rehabilitation Uptake Maximisation Study (BRUM). Home-based compared with hospital-based cardiac rehabilitation in a multi-ethnic population: cost-effectiveness and patient adherence. *Health Technol Assess* 2007;11:1–118.
37. Kassaian M, Maleki M, Noohi F, *et al*. Comparing effects of supervised vs. home-based cardiac rehabilitation. *Iran Heart J* 2000;1:95–102.
38. Marchionni N, Fattirolli F, Fumagalli S, *et al*. Improved exercise tolerance and quality of life with cardiac rehabilitation of older patients after myocardial infarction: results of a randomized, controlled trial. *Circulation* 2003;107:2201–6.
39. Sparks KE, Shaw DK, Eddy D, *et al*. Alternatives for cardiac rehabilitation patients unable to return to a hospital-based program. *Heart Lung* 1993;22:298–303.
40. Wu SK, Lin YW, Chen CL, *et al*. Cardiac rehabilitation vs. home exercise after coronary artery bypass graft surgery: a comparison of heart rate recovery. *Am J Phys Med Rehabil* 2006;85:711–17.
41. Moholdt T, Bekken Vold M, Grimsmo J, *et al*. Home-based aerobic interval training improves peak oxygen uptake equal to residential cardiac rehabilitation: a randomized, controlled trial. *PLoS ONE* 2012;7:e41199.
42. Oerkild B, Frederiksen M, Hansen JF, *et al*. Home-based cardiac rehabilitation is as effective as centre-based cardiac rehabilitation among elderly with coronary heart disease: results from a randomised clinical trial. *Age Ageing* 2011;40:78–85.
43. Smith KM, McKelvie RS, Thorpe KE, *et al*. Six-year follow-up of a randomised controlled trial examining hospital versus home-based exercise training after coronary artery bypass graft surgery. *Heart* 2011;97:1169–74.
44. American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR). Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs 5th edition, Champaign, IL: Human Kinetics, 2005. In: Association of Chartered Physiotherapists in Cardiac Rehabilitation (ACPICR) 2015. Standards for physical activity and exercise in the cardiovascular population: 2015, 3rd edition (appendix E, p45-46). http://acpicr.com/sites/default/files/ACPICR%20Standards%202015.pdf (accessed 26 May 2016).
45. Stewart S, Carrington MJ, Horowitz JD, *et al*. Prolonged impact of home versus clinic-based management of chronic heart failure: extended follow-up of a pragmatic, multicentre randomized trial cohort. *Int J Cardiol* 2014;174:600–10.
46. Maru S, Byrnes J, Carrington MJ, *et al*. Cost-effectiveness of home versus clinic-based management of chronic heart failure: extended follow-up of a pragmatic, multicentre randomized trial cohort—The WHICH? study (Which Heart Failure Intervention Is Most Cost-Effective & Consumer Friendly in Reducing Hospital Care). *Int J Cardiol* 2015;201:368–75.
47. Jaarsma T, Strömberg A. Heart failure clinics are still useful (more than ever?). *Can J Cardiol* 2014;30:272–5.

48. Menezes AR, Lavie CJ, Milani RV, *et al*. Cardiac rehabilitation in the United States. *Prog Cardiovasc Dis* 2014;56:522–9.
49. Jelinek MV, Thompson DR, Ski C, *et al*. 40 years of cardiac rehabilitation and secondary prevention in post-cardiac ischaemic patients. Are we still in the wilderness? *Int J Cardiol* 2015;179:153–9.
50. Forman DE, Sanderson BK, Josephson RA, *et al*, American College of Cardiology's Prevention of Cardiovascular Disease Section. Heart failure as a newly approved diagnosis for cardiac rehabilitation: challenges and opportunities. *J Am Coll Cardiol* 2015;65:2652–9.
51. Lavie CJ, Arena R, Franklin BA. Cardiac rehabilitation and healthy life-style interventions: rectifying program deficiencies to improve patient outcomes. *J Am Coll Cardiol* 2016;67:13–15.
52. Wingham J, Dalal HM, Sweeney KG, *et al*. Listening to patients: choice in cardiac rehabilitation. *Eur J Cardiovasc Nurs* 2006;5:289–94.
53. Ades PA, Keteyian SJ, Balady GJ, *et al*. Cardiac rehabilitation exercise and self-care for chronic heart failure. *JACC Heart Fail* 2013;1:540–7.
54. Buck HG, Harkness K, Wion R, *et al*. Caregivers' contributions to heart failure self-care: a systematic review. *Eur J Cardiovasc Nurs* 2015;14:79–89.
55. Clark AM, Spaling M, Harkness K, *et al*. Determinants of effective heart failure self-care: a systematic review of patients' and caregivers' perceptions. *Heart* 2014;100:716–21.
56. Healthcare Commission. *Coronary heart disease: survey of patients*. Healthcare Commission, 2004. http://www.nhssurveys.org/Filestore/CQC/CHD_KF_2004.pdf
57. Grace SL, Gravely-Witte S, Brual J, *et al*. Contribution of patient and physician factors to cardiac rehabilitation enrolment: a prospective multilevel study. *Eur J Cardiovasc Prev Rehabil* 2008;15:548–56.
58. Grace SL, McDonald J, Fishman D, *et al*. Patient preferences for home-based versus hospital-based cardiac rehabilitation. *J Cardiopulm Rehabil* 2005;25:24–9.
59. Ades PA, Waldmann ML, McCann WJ, *et al*. Predictors of cardiac rehabilitation participation in older coronary patients. *Arch Intern Med* 1992;152:1033–5.
60. Smith KM, Arthur HM, McKelvie RS, *et al*. Differences in sustainability of exercise and health-related quality of life outcomes following home- or hospital-based cardiac rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2004;11:313–9.
61. Taylor RS, Watt A, Dalal HM, *et al*. Home-based cardiac rehabilitation versus hospital-based rehabilitation: a cost effectiveness analysis. *Int J Cardiol* 2007;119:196–201.